

Swift Observation of GRB 090510

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1 Introduction

At 00:23:00 UT BAT triggered on GRB 090510 (Trigger 351588, Hoversten, *et al.*, *GCN Circ.* 9331). GRB 090510 is a short hard burst with $T_{90} = 0.3 \pm 0.1$ seconds. Swift slewed immediately to this burst. XRT began follow-up observations at $T + 94.1$ seconds and UVOT began observations at $T + 97$ seconds. Our best position is the UVOT detection of the early afterglow in the u band at the position $RA(J2000) = 333.55208 \text{ deg}$ (22h14m12.5s), $Dec(J2000) = -26.58311 \text{ deg}$ ($-26d34'59.2''$) with an uncertainty of 0.61 arcsec (radius, 90% confidence).

GRB 090510 was also detected by many other observatories. It was seen by Fermi with both the GBM (Guiriec, *et al.*, *GCN Circ.* 9336) and LAT (Ohno & Pelassa, *GCN Circ.* 9334) instruments. Other high energy detections include AGILE (Longo, *et al.*, *GCN Circ.* 9343), Konus-Wind (Golenetskii, *et al.*, *GCN Circ.* 9344), Suzaku WAM (Ohmori, *et al.*, *GCN Circ.* 9355), and INTEGRAL/SPI-ACS (V. Savchenko, private communication). LAT detected GeV photons at the 5σ level and AGILE detected photons with energies above 100 MeV for the first time for a short burst. Additional observations include optical detections by the Nordic Optical Telescope (Olofsson, *et al.*, *GCN Circ.* 9338) and GROND (Olivares, *et al.*, *GCN Circ.* 9352). An upper limit was found at 8.46 GHz by the VLA (Frail & Chandra, *GCN Circ.* 9354). A spectroscopic redshift of $z = 0.903$ was measured by VLT/FORS2 (Rau, *et al.*, *GCN Circ.* 9353).

2 BAT Observation and Analysis

Using the data set from $T - 60$ to $T + 243$ seconds, further analysis of BAT GRB 090510 has been performed by Swift team (Ukwatta, *et al.*, *GCN Circ.* 9337). The BAT ground-calculated position is $RA(J2000) = 333.552 \text{ deg}$ (22h14m12.6s), $Dec(J2000) = -26.598 \text{ deg}$ ($-26d35'51.1''$) with an uncertainty of 1.7 arcmin, (radius, systematic and statistical, 90% containment). The partial coding was 16%.

The mask-weighted light curve (Figure 1) shows a small precursor peak at $T - 0.54$ s (width ~ 30 ms). Then the main peak starts at $T - 0.05$ s and peaks at $T + 0.04$ s with a width of ~ 50 ms. Then come two smaller peaks at $T + 0.24$ and $T + 0.32$ s, each about 40 ms in width. At the 3σ level, there is the possibility of low-level emission between $T + 110$ s to $T + 170$ s. T_{90} (15-350 keV) is 0.3 ± 0.1 s (estimated error including systematics).

The time-averaged spectrum from $T + 0.0$ to $T + 0.4$ s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 0.98 ± 0.20 . The fluence in the 15-150 keV band is $3.4 \pm 0.4 \times 10^{-7} \text{ erg cm}^{-2}$. The 1 s peak photon flux measured from $T - 0.30$ s in the 15-150 keV band is $9.7 \pm 1.1 \text{ ph cm}^{-2} \text{ s}^{-1}$. All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

The UVOT enhanced XRT position is $RA(J2000) = 333.55271 \text{ deg}$ (22h14m12.65s), $Dec(J2000) = -26.58266 \text{ deg}$ ($-26d34'57.6''$) with an uncertainty of 1.4 arcsec (radius, 90% confidence, Goad, *et al.*, *GCN Circ.* 9339). This position is within 3.8 arcsec of the initial XRT position.

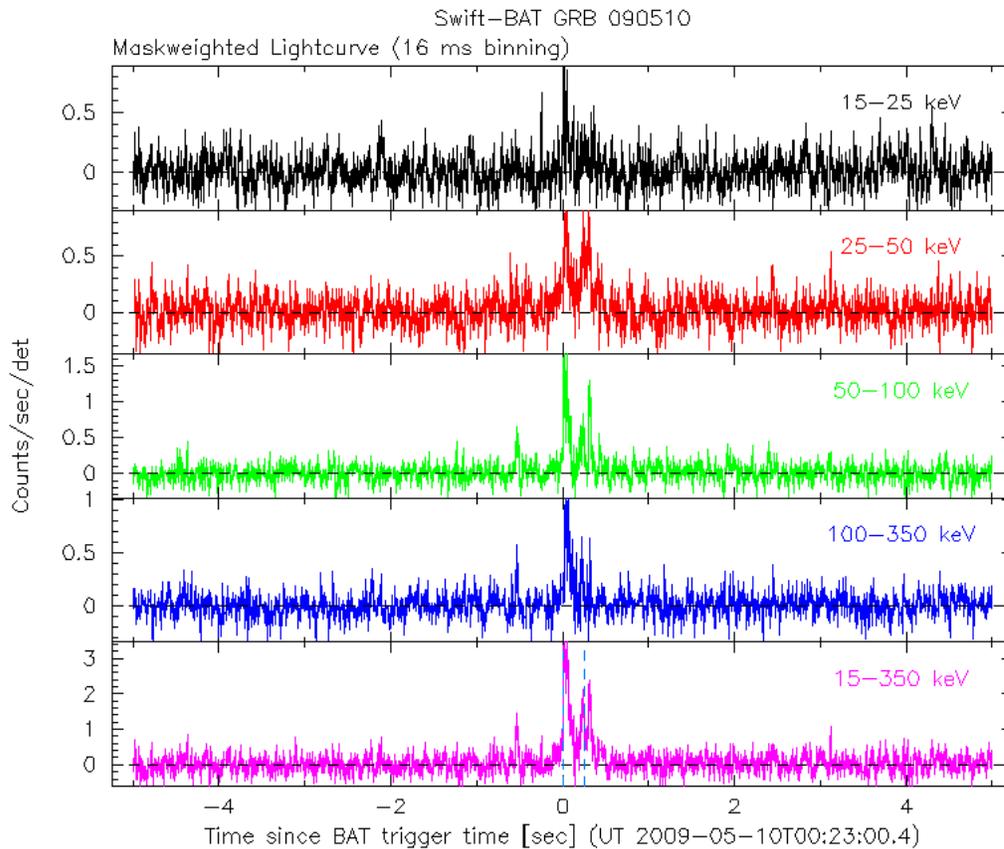


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/s/illuminated-detector (note illum-det = 0.16cm^2) and T_0 is 00:23:00.4 UT.

The 0.3-10 keV light curve (Fig.2) can be modelled with a broken power-law decay with an index of $\alpha = 0.77 \pm 0.05$, followed by a break at $T + 1470 \pm 160$ s and then an index of $\alpha = 2.16_{-0.14}^{+0.17}$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of 1.57 ± 0.08 with an absorption column consistent with the Galactic value of $1.66 \times 10^{20} \text{cm}^{-2}$ (Kalberla, et al. 2005). The PC mode spectrum is consistent with this result.

4 UVOT Observation and Analysis

The Swift UltraViolet/Optical Telescope (UVOT) began observations of the short hard burst GRB 090510 on May 10, 2009, at 00:24:24 UT, 80 seconds after the BAT trigger with a settling exposure in the UVOT v filter (Kuin & Hoversten, *GCN Circ.* 9342).

A new optical source was found by the UVOT (Marshall & Hoversten, *GCN Circ.* 9332). The position of the source is $\text{RA}(J2000) = 333.55208 \text{ deg}$ ($22\text{h}14\text{m}12.5\text{s}$), $\text{Dec}(J2000) = -26.58311 \text{ deg}$ ($-26\text{d}34'59.2''$) with an uncertainty of $0.61''$ (90% confidence). The UVOT position is offset $1.6''$ from the refined XRT position (Goad, et al., *GCN Circ.* 9339) and is consistent with the revised NOT position (Malesani, *GCN Circ.* 9340) to within $0.2''$

GRB 090510 is detected in all UVOT filters, except perhaps in b, which implies that the redshift is less

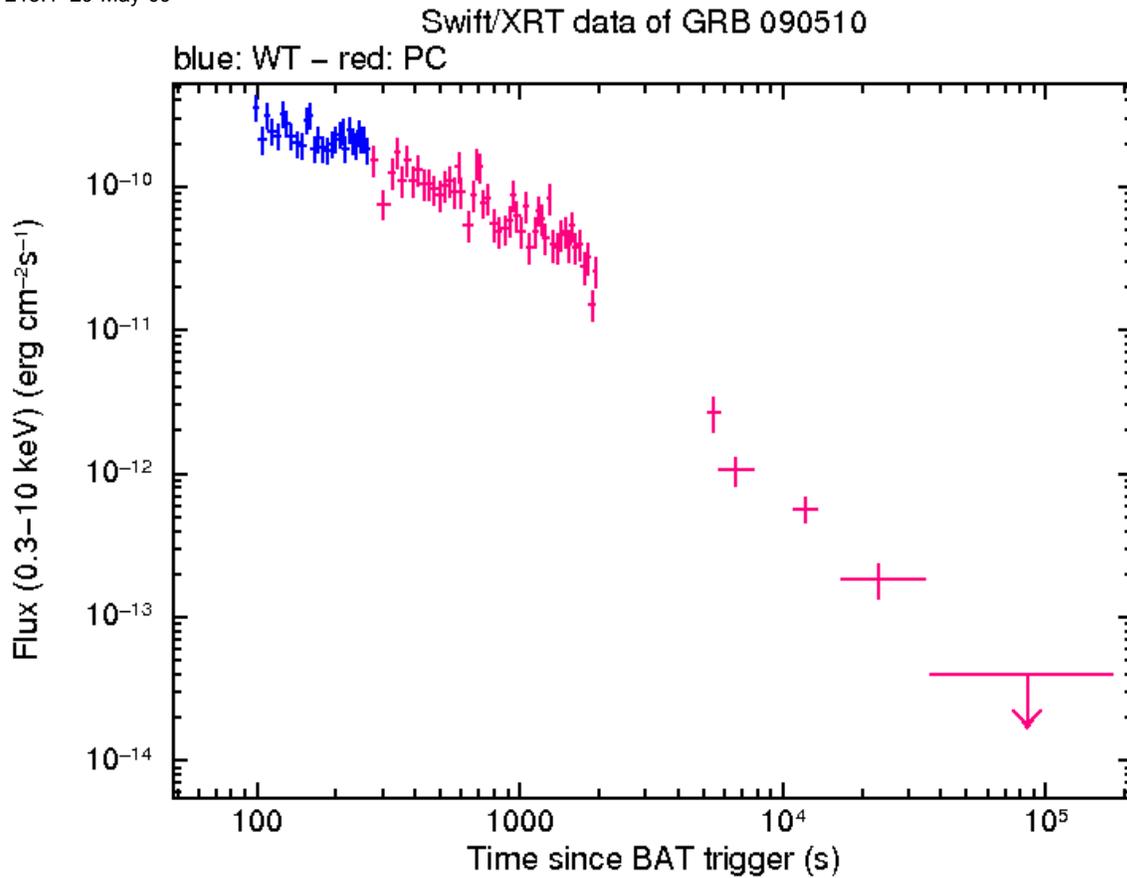


Figure 2: XRT Lightcurve. Flux in the 0.3-10 keV band: Window Timing mode (blue), Photon Counting mode (red). The approximate conversion is $1 \text{ count/s} \simeq 4.3 \times 10^{-11} \text{ ergs cm}^{-2} \text{ s}^{-1}$.

than about 1.5 which is in agreement with the spectroscopic redshift of $z = 0.9$. The emission is seen to rise to a peak around 600s after the trigger. A light curve with white and v band data is given in Figure 3. The initial magnitude observed in the UVOT filters are given in Table 1. The values quoted in the table are on the UVOT Photometric System (Poole, et al, 2008). They are not corrected for the expected galactic reddening of $E(B - V) = 0.020$ in the direction of the burst (Schlegel, Finkbeiner, & Davis, 1998).

References

- [1] Frail, D. A. & Chandra, P. 2009, *GCN Circ.* 9354
- [2] Goad, M. R., et al. 2009, *GCN Circ.* 9339
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- [7] Kuin, N. P. M., & Hoversten, E. A. 2008, *GCN Circ.* 9342
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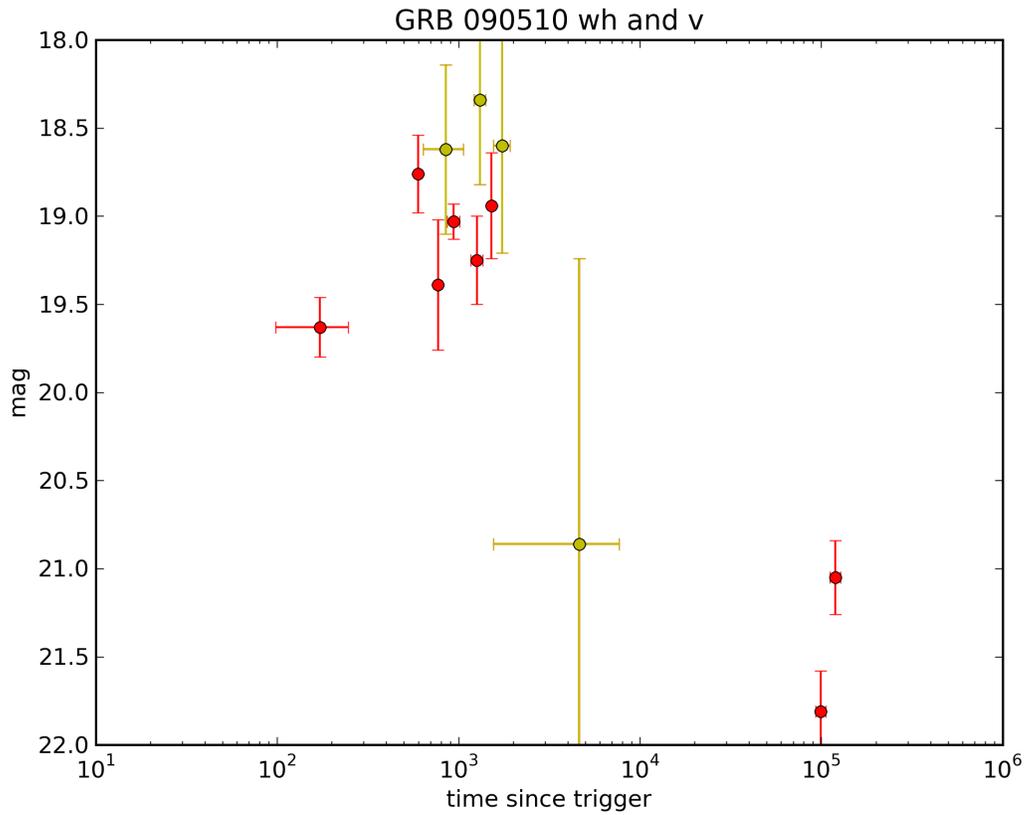


Figure 3: UVOT Lightcurve. Magnitudes are shown for the white (red points) and v (gold points) band observations.

- [9] Malesani, D. 2009, *GCN Circ.* 9340
- [10] Ohno, M., & Pelassa, V. 2009, *GCN Circ.* 9334
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- [16] Ukwatta, T. N., et al. 2009, *GCN Circ.* 9337

Filter	Start	Stop	Exposure	Magnitude
white	97	247	147.4	19.63 ± 0.17
white	588	608	19.5	18.76 ± 0.22
white	1167	1526	58.3	19.16 ± 0.20
v	638	1410	97.3	18.46 ± 0.33
b	564	1502	97.2	$> 19.62 (2.2\sigma)$
u	712	1477	323.6	19.05 ± 0.17
uvw1	687	1452	75.9	18.61 ± 0.27
uvm2	662	1434	93.7	18.10 ± 0.22
uvw2	614	1552	115.4	18.31 ± 0.18

Table 1: UVOT observations